HUMAN DECOMPOSITION SCENT DETECTION

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AREAS COVERED

- Canine Scent Detection
- Human Decomposition
- Videos of Dogs
- Accuracy of Alerts
- Probability of Detection
- Probability of False Positive
- How to Select a HHRD Search Team
- Future Directions
CANINE SCENT DETECTION

- Dog can be trained to find many things by scent
  - Drugs
  - Explosives
  - Cancer
  - Bed Bugs
  - Live People
  - Recent Corpses
  - Old Human Burials (HHRD)

- Types of HHRD Searches
  - Locate Cemetery Boundaries
  - Locate Native American Burial Areas
  - Locate Unmarked Graves
  - Locate Where People Died and Weren’t Buried
CANINE NOSE

• Human
  • 5 Million olfactory receptors
  • Sensitivity: Parts per million
  • Teaspoon sugar in cup of water
  • Single odor overwhelms human nose
  • Can’t tell direction

• Canine
  • 300 Million olfactory receptors
  • Sensitivity: One part per trillion
  • Teaspoon sugar in million gallons of water
  • Multiple odors simultaneously
  • Directional scenting
CANINE NOSE

- Specially constructed to maximize scent detection
- Breathes in through nostrils
- Breathes out though slits in side of nose
- Doesn’t disturb scent in front of nose
HUMAN DECOMPOSITION

• When a person dies
  • Their body breaks down into numerous volatile organic compounds (VOC’s)
  • The VOC’s saturate the bones and surrounding soil
  • VOC’s are detectable for centuries after death
  • Human decomposition contains different VOC’s than animal decomposition
  • Burials can be detected even after the bones are removed
  • If the body decomposes on the surface, animal activity dismembers body and scent is scattered around the death location
<table>
<thead>
<tr>
<th>Rank</th>
<th>Compound</th>
<th>Concentration (ppt*)</th>
<th>Compound Detection BADD† Range</th>
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n.d., none detected.
* ppt, parts per trillion.
† BADD, burial accumulated degree days.
‡ Not detected during surface decomposition.
• Most animals have similar decomposition VOC’s

• We have no idea which VOC’s dogs detect to determine human decomposition

• In this table humans are closest to chickens

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CANINE SCENT DETECTION

- Historic Human Remains Detection (HHRD) dogs are trained to find old human burials
- Dogs detect VOC’s when they evaporate into the air column
- Accuracy limited by path VOC’s take to reach the surface
- Dogs can work in areas not accessible to more traditional geophysical techniques
- Dogs can detect very old human burials
  - Oldest burial detected by ICF dogs radiocarbon dated at 9,000 years
CANINE LIMITATIONS

• Ground must be permeable for scent to reach the surface
  • Can’t detect burials through solid surfaces except at cracks

• Ground temperature critical factor
  • Sun heats ground more than air
  • Best working range is 40-80°F ground temperature
  • Can work at 100°F with some loss in Probability of Detection

• Moisture in ground can help
  • Evaporation pulls scent to surface

• Light wind is good; strong wind blows scent away

• Light rain is not a problem; heavy rain seals scent in soil
CANINE TRAINING

• Training can start at any age
  • Many dogs are imprinted with scent as a puppy
  • Oldest dog to certify in ICF started training at 7 years

• Dog must have desire to work
  • Most dogs come from working dog lines
  • Other breeds have been trained

• Different training techniques can be successful
  • Most are based on positive reinforcement
  • Dog finds scent and rewarded with treat or toy
CEMETERY TESTING

• Dogs must be tested to determine accuracy detecting graves
  • Dogs work site with no information about location
  • Grave location determined by geophysical or excavation

• Studies
  • 19th Century Cemetery
  • Army Corps of Engineers Study
  • Native American Burial Area
19th Century Cemetery

- Dog Alerts Shown in Red
- Grave Shafts Shown in Gray
  - Determined by GPR
- Burials Likely Shallow, < 1m
- No Visible Burial Markers

Key Points
- Dogs do not find every burial
- Most alerts are close, but a few are larger misses
- RMS Error is ~2 meters
FORT GORDON CEMETERIES

• Dogs tested by Army Corps of Engineers
• Early 20th Century Family Graveyards
• No surface indication of burial locations
• Grave shaft positions determined by Ground Penetrating Radar and magnetic gradiometer
• Some of the anomalies are likely not burials
• GPR can’t distinguish burial shafts from other ground disturbances
• Report available on ICF website
CEMETERY 9

- Soil is loose fine sand
- Cemetery fence shown on map
- The dogs indicate there may be additional burials northwest of the road
- This northwest area is forested and not surveyed using geophysical methods
CEMETERY 20

- Located in a wooded area
- The GPR data less consistent than other sites
- Some of these anomalies less likely to be real graves
- Most alerts within 4 meters of possible grave
CEMETERY 26

- Site is a forested area
- Anomalies on the east side are most likely to be graves
- Only two dogs alerted at this site, both on eastern side
CEMETERY 31

- Wooded area with some bricks embedded in the surface
- Highly likely that burials are present in this area
- All of the dogs alerted near suspected graves
- Several alerts 10 meters from any suspected grave
CEMETERY 34

- Approximately 30 GPR anomalies identified as possible graves
- The dog alerts clustered in the southern half of the search area
FORT GORDON CEMETERIES

• Army Corps of Engineers Conclusions
  • Dogs alerted within 1 meter of a possible graves in all of the cemeteries
  • 61% of the alerts were within 4 meters of a possible grave
  • Dog teams are an effective way to survey a large area
  • Dogs are not effective at locating individual burials
  • Geophysical survey can then focus on areas identified by the dogs as containing human burials

• Overall statistics of Fort Gordon cemetery searches
  • RMS Error: 3.8 meters
  • Median of alert errors: 2.8 meters
  • Maximum error: 13 meters
NATIVE AMERICAN BURIAL AREA

- Graves 500-600 years old
- Burials excavated
- Likely shallow burials
- Burial 68 clearly missed
- RMS Error 1.6 meters
PROBABILITY OF DETECTION

• For a Dog To Detect a Grave
  • Scent Must Reach Air Column

• Probability of Detecting Grave Varies
  • Age of Burial
  • Soil Conditions
    • Soil Must Allow VOC’s to Evaporate
  • Local Weather
    • Air & Ground Temperature, Humidity, Wind, Sun, Rain
  • Depth of Burial

• Impossible to measure due to unknown location of old graves
PROBABILITY OF FALSE POSITIVE

- Not All Alerts Are Correct
- Scent Can Collect Downwind From a Source
- Dogs Can Be Fooled By a Combination of Scents Close To Their Trained Scent
- Dogs and Humans Can Get Frustrated
BOX SEARCH EXPERIMENT

• Test for False Positive Rate
• Large Collection in Boxes
  • Archaeology collection, some from area of graves
  • Checked for decomposition scent by 3 dogs
• 182 Boxes Searched
  • 7 had alerts by all 3 dogs
  • 7 had alerts by 2 dogs
  • 8 had alerts by 1 dog
  • 160 had no alerts
BOX SEARCH EXPERIMENT

• If Single Dog Alerts Incorrect
  • Can estimate Detection & False Positive Rates
  • Probability False Positive 4.4%
  • Probability of Detection 83%
CURSE OF FALSE POSITIVES

- Dogs can be influenced by handler beliefs
- Experiment at UC Davis to test this bias
  - 18 handler/dog teams tested in two separate runs in four areas
  - Dogs certified for either drug or explosive detection
  - Handlers falsely told that the test area contained up to three sources of their trained scent; no scent sources were present
  - 85% of the tests had one or more alerts (False Positive)
- Significant issue for search dogs
- ICF has training procedures to minimize False Positives
  - Dogs must work areas with no sources without alerts
  - Some of these tests are blind to the handler
SUMMARY GRAVE DETECTION

• Dogs can find human burials thousands of years old

• Most alerts within 4 meters of burial
  • General rule is RMS Error is twice burial depth
  • Statistically 68% of the alerts should be within the RMS Error

• Do not alert at all burials when close together, such as cemetery

• Working multiple dogs
  • Improves Probability of Detection
  • Decreases Probability of False Positive

• Dogs can work 1 to 2 acres per hour
  • Generally require a rest break of 1 hour for each hour worked
ICF CERTIFICATION

• Required Skills
  • Efficacy problem to locate multiple target scents (10 per year) with efficacy >75%
  • Grave detection in cemetery (6 per year)
  • Problem with negative sources (4 per year)
  • One acre test for either 0 or 1 human bones (2/year)
  • Search area with no sources for 45 minutes (2/year)
  • Locate 10 human teeth in 15 minutes (2/year)

• Training Requirements
  • Training is scheduled 3 times per week
  • Regularly attend training
  • Work at least 75 training problems per year
HOW TO SELECT A SEARCH TEAM

• Not All Search Teams Are Effective At HHRD

• Hiring Agency Must Ask Questions
  • Are dogs certified to a standard? Who evaluates the dogs?
  • Have the dogs been tested by a professional organization?
  • What target scents are the dogs trained to find (fewer is better)?
  • What professional papers have been published on canine projects?
  • Do you prepare Client Reports? Samples?
  • How many projects per year?
  • Who are your clients?
  • References?
Max Planck Institute for Evolutionary Anthropology

- Developed a method to recover human DNA from soil samples
- Recovered Neanderthal and Denisovan mtDNA fragments from soil in caves with age of ~100,000 years
- DNA fragment density about the same as in human bone
- DNA fragments reconstructed in computer analysis
- Could eventually be applied to nuclear DNA
DNA RECOVERY

• When a human body decomposes
  • Releases DNA fragments into the surrounding soil
  • Also releases the VOC’s that the dogs detect

• HHRD canines may also be used as DNA detectors

• ICF in discussions about a project to use this method

• Cost is currently very expensive
  • Likely to drop to reasonable level within next few years
  • Ability to identify individuals in unknown burials
QUESTIONS